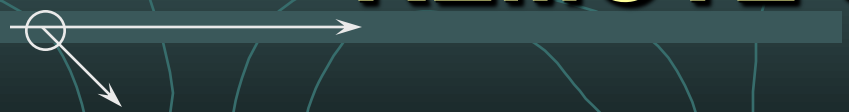
INTRODUCTION TO REMOTE SENSING



What is Remote Sensing?

Remote sensing is the science (and to some extent, art) of acquiring information about the Earth's surface without actually being in contact with it.

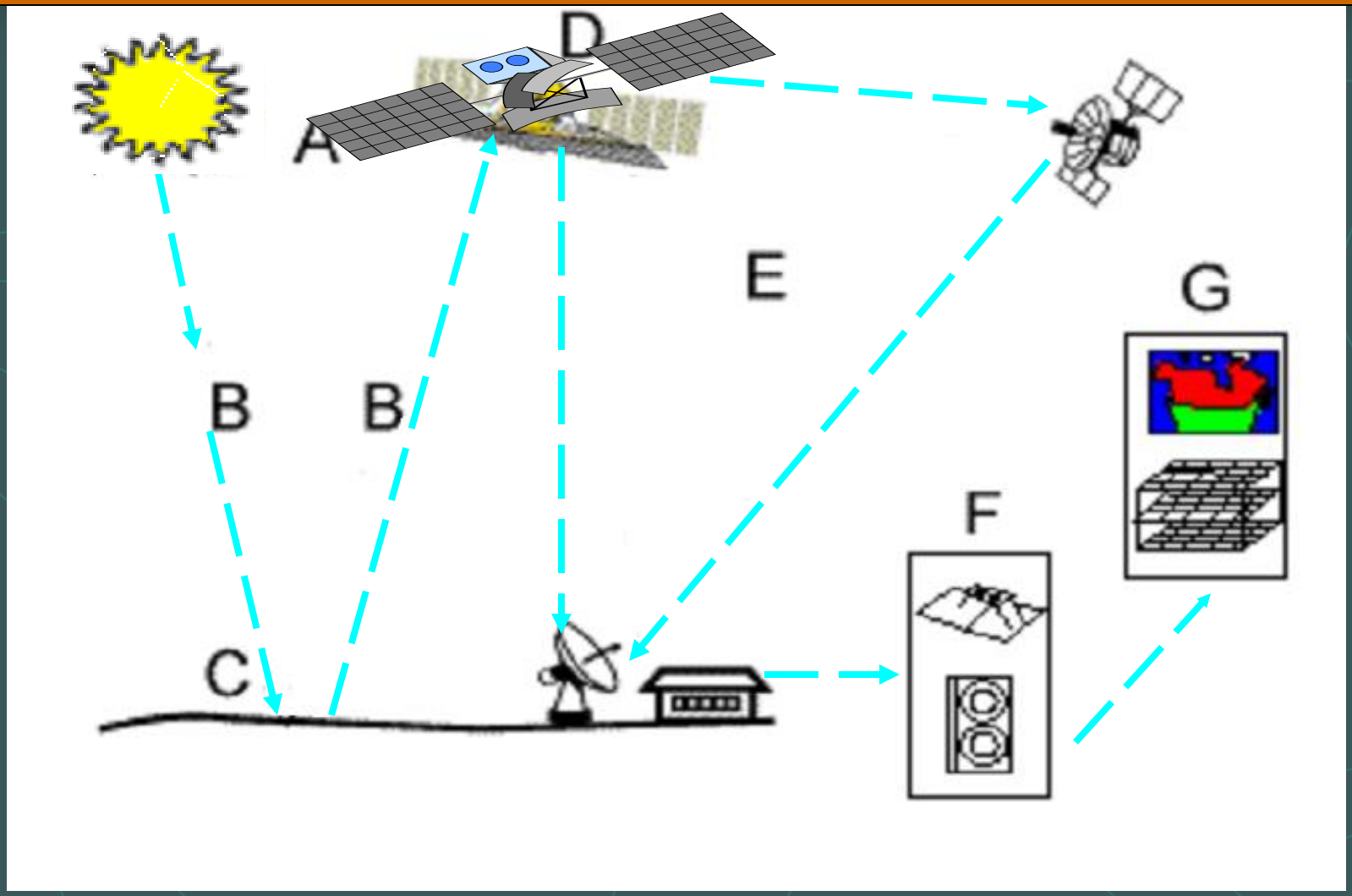
This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information

What is really involved?

An interaction between incident radiation and the targets of interest

Also involves the sensing of emitted energy and the use of non-imaging sensors

BASIC PRINCIPLES IN REMOTE SENSING DATA COLLECTION



A : **Radiation source** B : **Atmosphere** C : **Target** D : **Sensor**

E : **Transmission, reception** F : **Processing, interpretation**

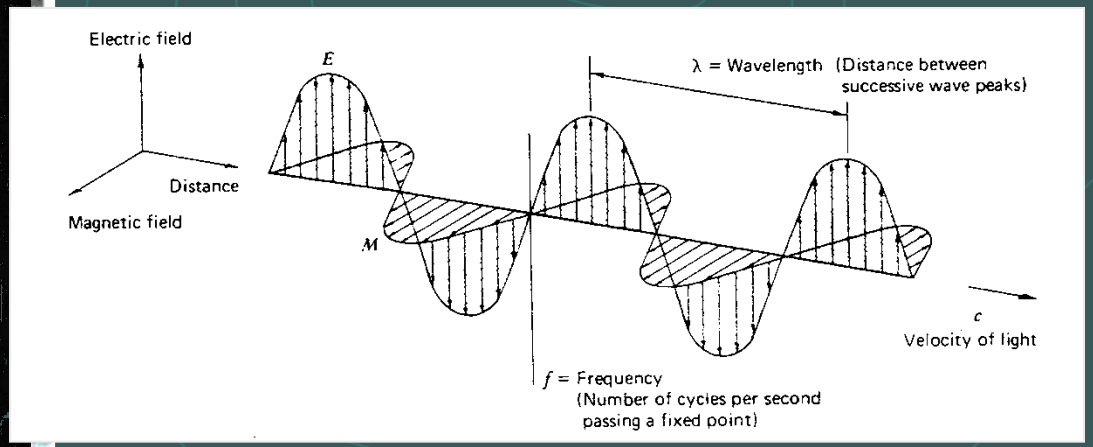
G :**Application**

Major Components of RS Technology

- Energy Source
  - Passive System: Irradiance from earth's materials
  - Active System: irradiance from artificially generated energy sources such as radar
- Platforms: Vehicle to carry the sensor
- Sensors: Device to detect electro-magnetic radiation
- Processing: Handling signal data
- Institutionalization (international and national organizations, centers, universities for execution at all stages of remote-sensing technology)

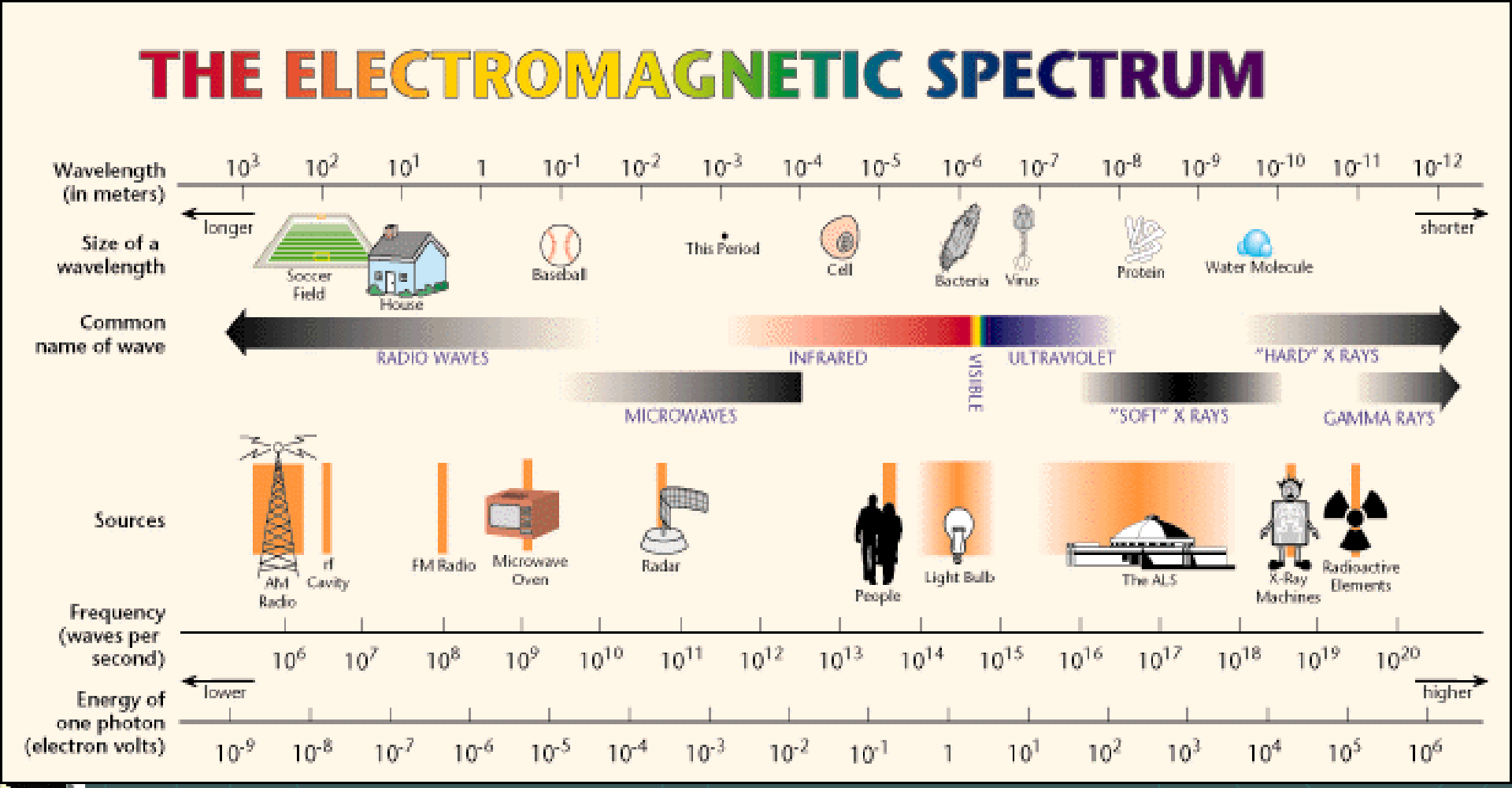
THE RADIATION SOURCE

- Everything on earth above **0** Kelvin of absolute temperature generates electromagnetic energy.
- The radiation of an object serves as a **signature** for its identification.
- The most obvious source of energy : **SUN**.



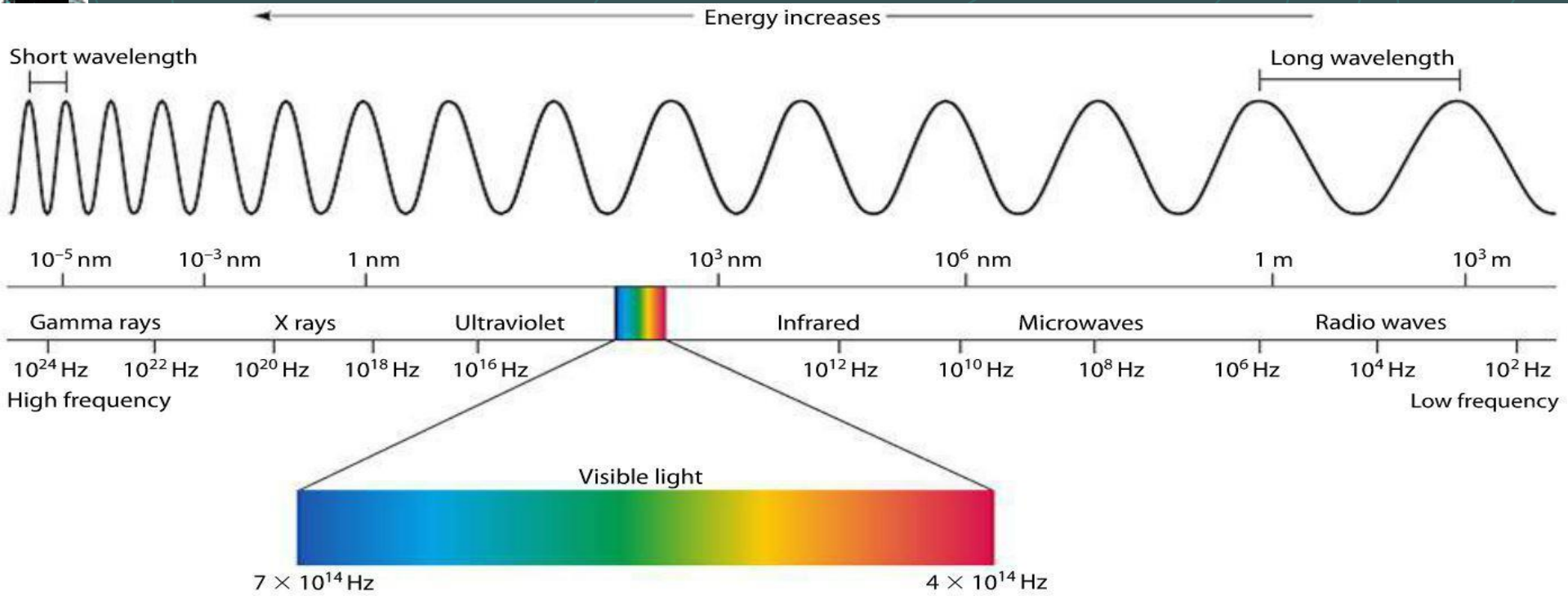
Basic wave theory

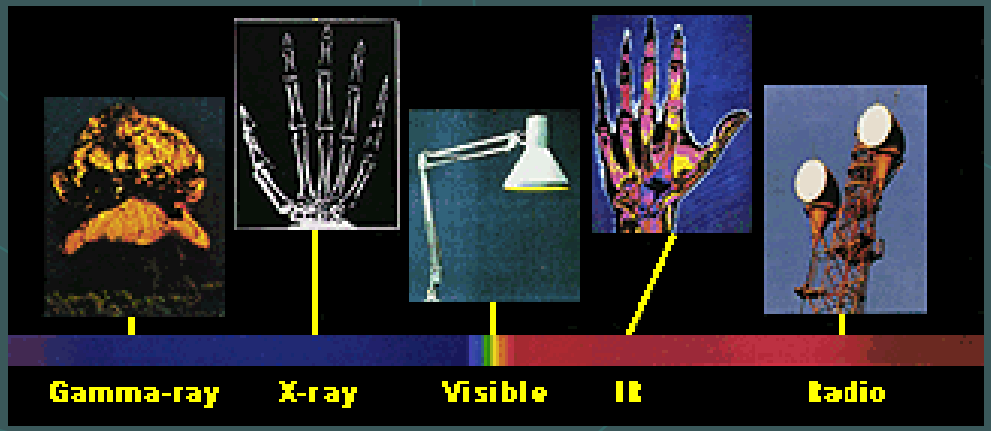
- E- and M- fields
- Wavelength λ, frequency f
- velocity of light c
- Energy content $E = hf$



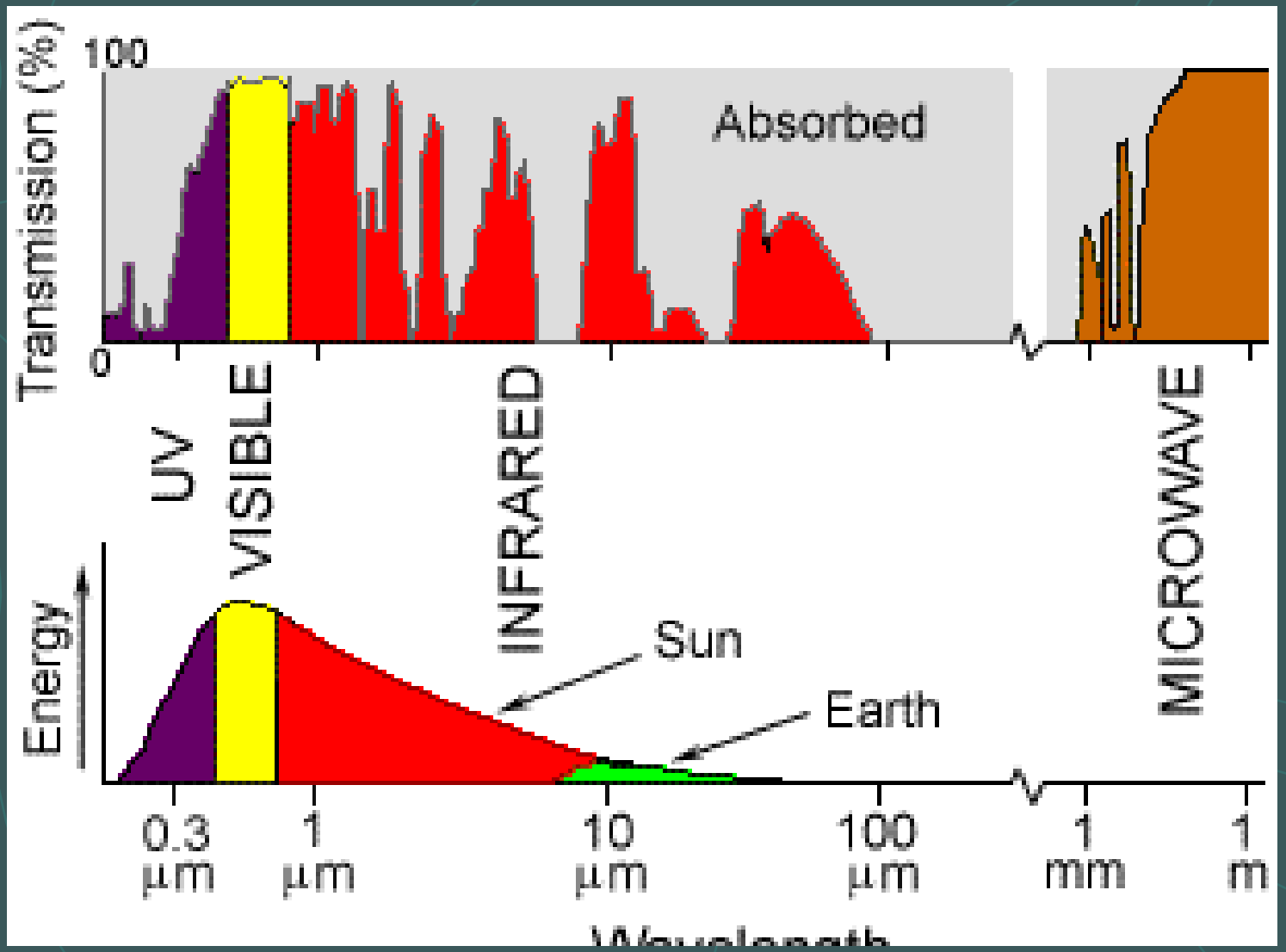
- Divided into regions ranging from short gamma rays to long radio waves.
- Several regions are useful for Remote sensing :

Electromagnetic (EM) Spectrum

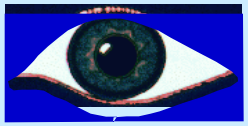




Electromagnetic (EM) Spectrum

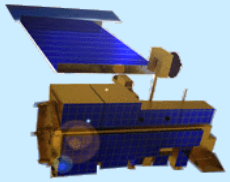


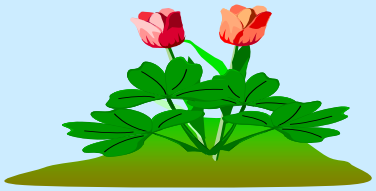
Remote Sensing Systems (Spectral Signal)

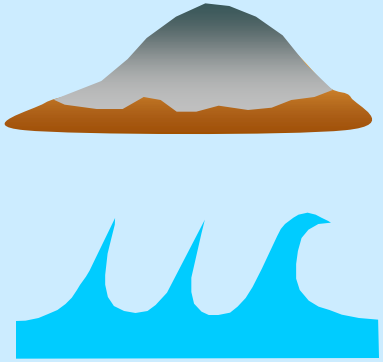


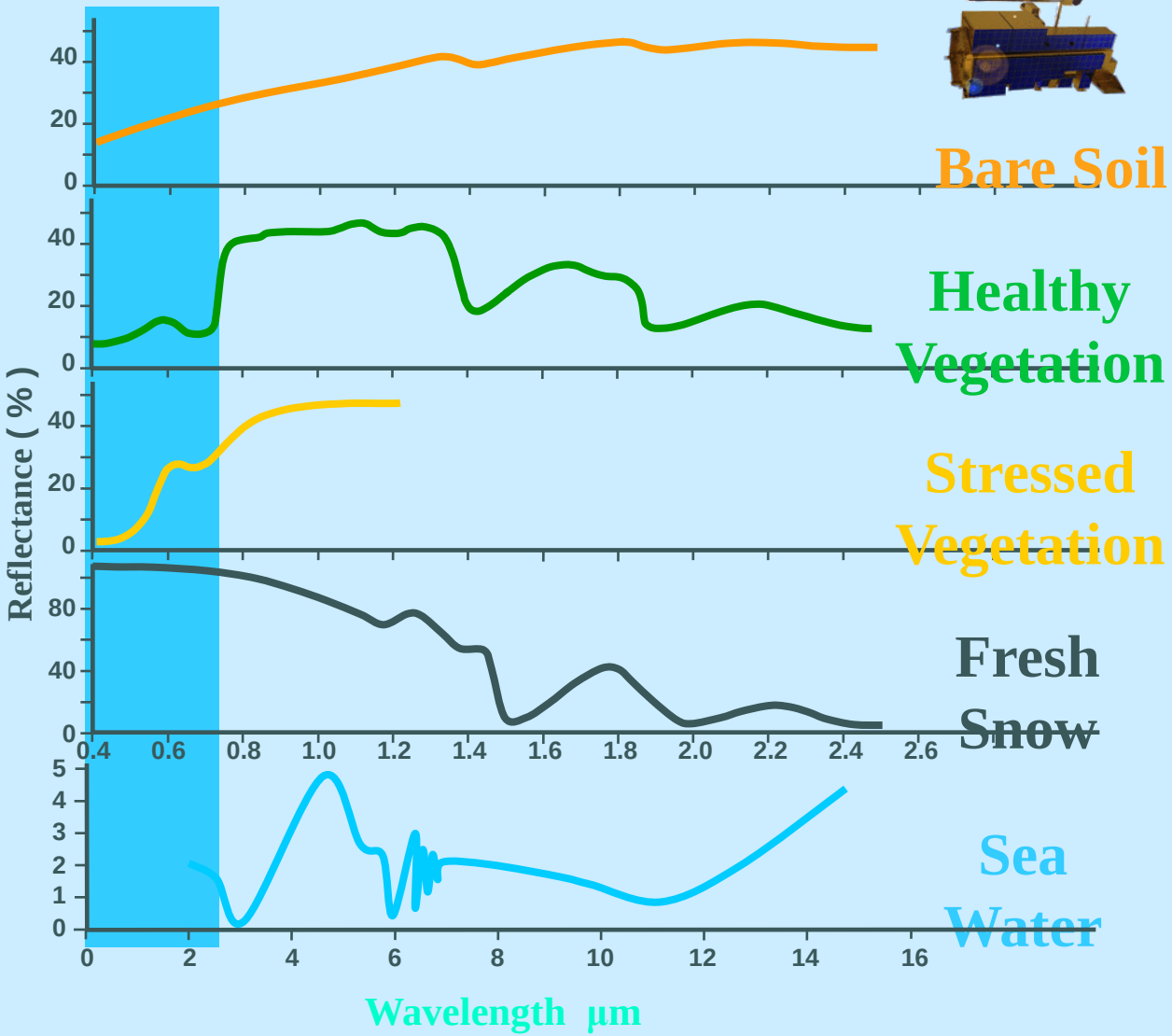
Human Eye

Satellite





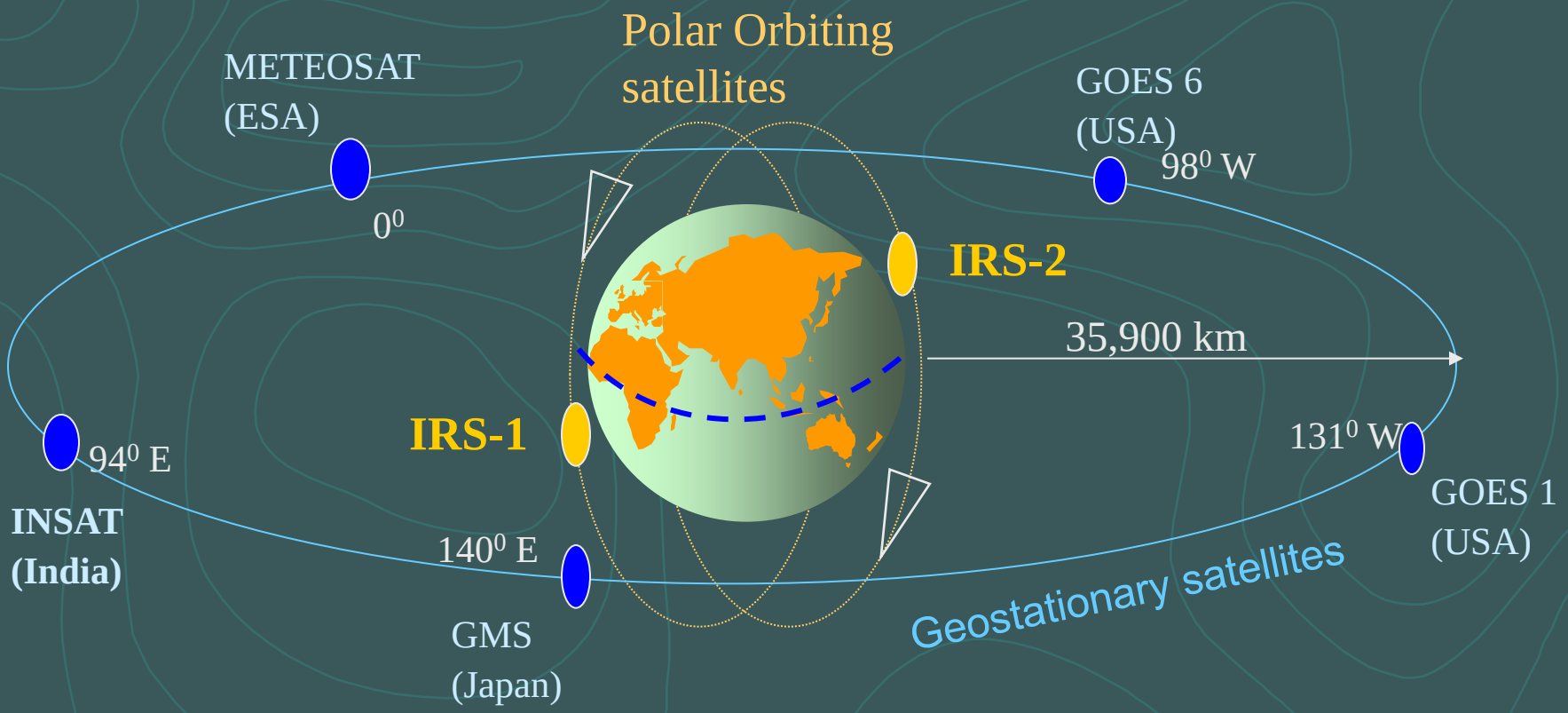




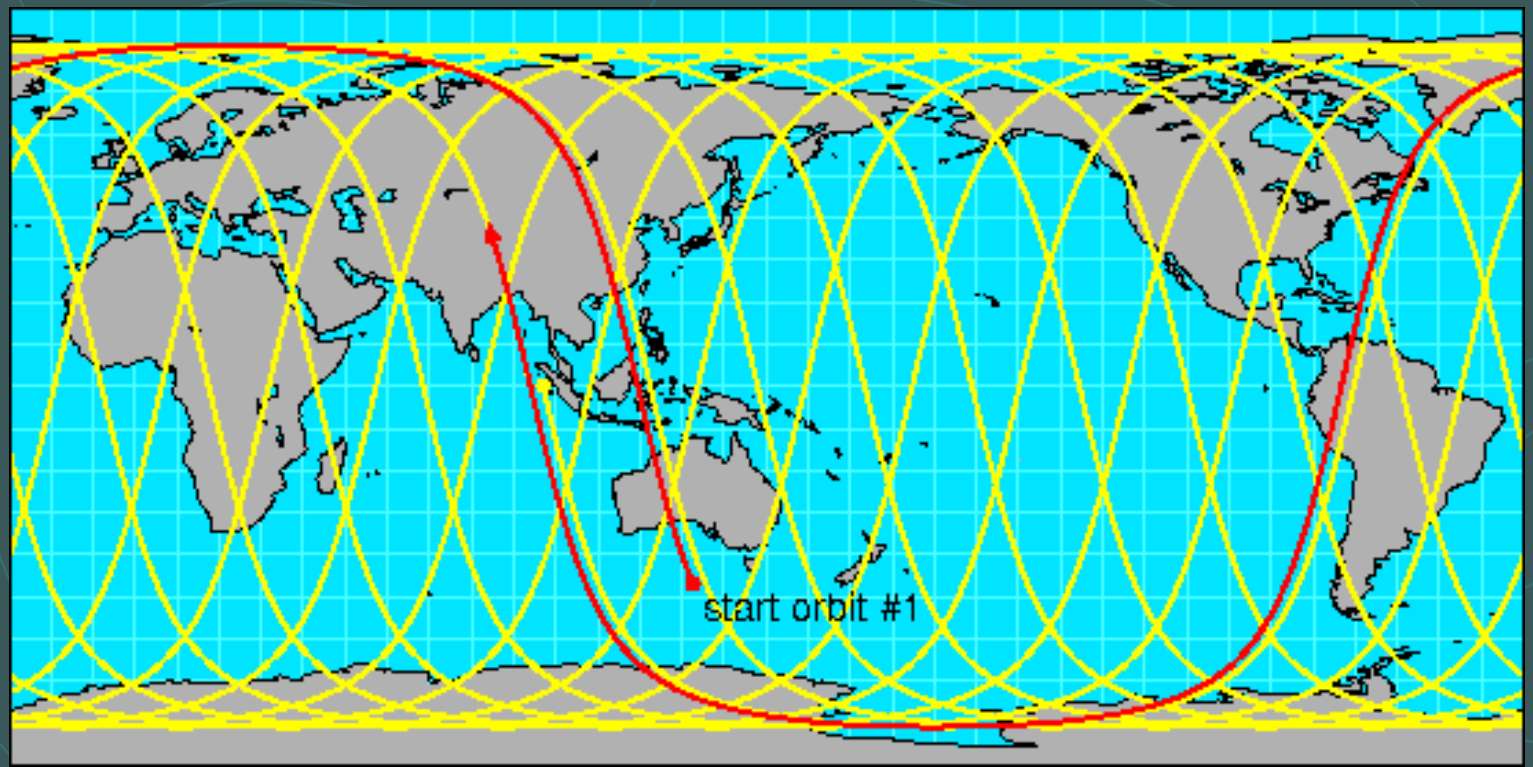
Remote Sensing Components and Considerations

- Energy Source or Illumination
- Radiation and the Atmosphere
- Interaction with the Target
- Recording of Energy by the Sensor
- Transmission, Reception, and Processing
- Interpretation and Analysis
- Application

SATELLITE ORBITS



SATELLITE ORBITS



DATA THAT CAN BE ACQUIRED

- Planimetric location
- Elevation
- Colour of objects
- Vegetation characteristics
- Soil moisture content
- Vegetation moisture content
- Temperature
- Soil texture
- Land use characteristics
- Water bodies
- Mineral deposits

DATA ACQUISITION PROCESS

- **STEP I**

  Capture data using sensors (cameras) mounted on satellites or aircrafts

- **STEP II**

  Record the observations on suitable media like magnetic tapes or photographic films

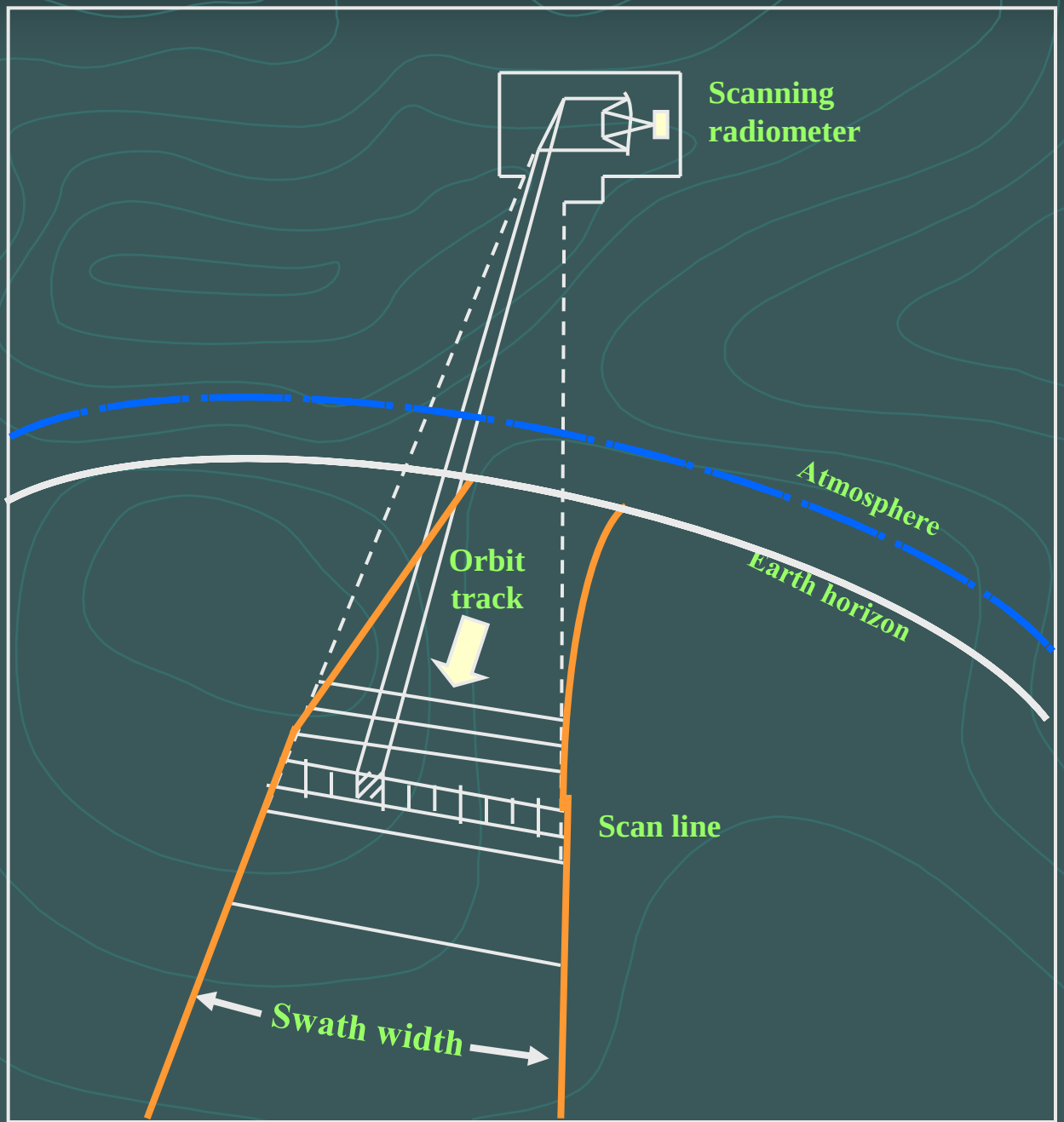
- **STEP III**

  Transmit data to earth station and remove errors

- **STEP IV**

  Generate output products in photo or digital formats and store in floppies or DATs

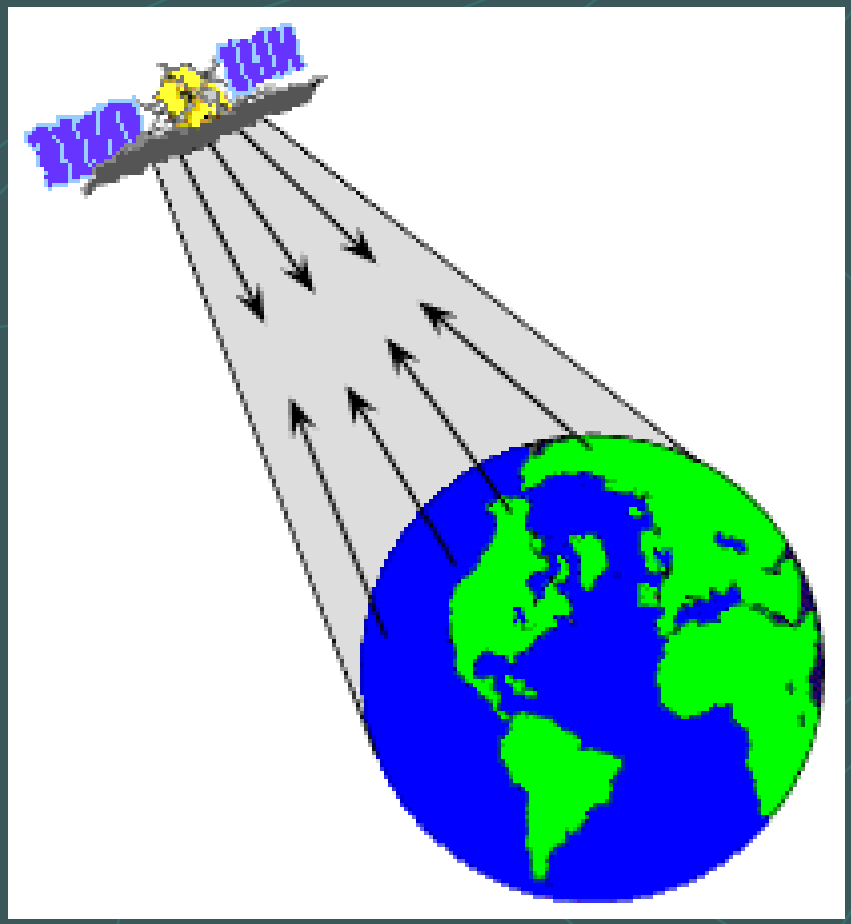
REMOTE SENSING SATELLITE



TYPES OF SENSORS

ACTIVE

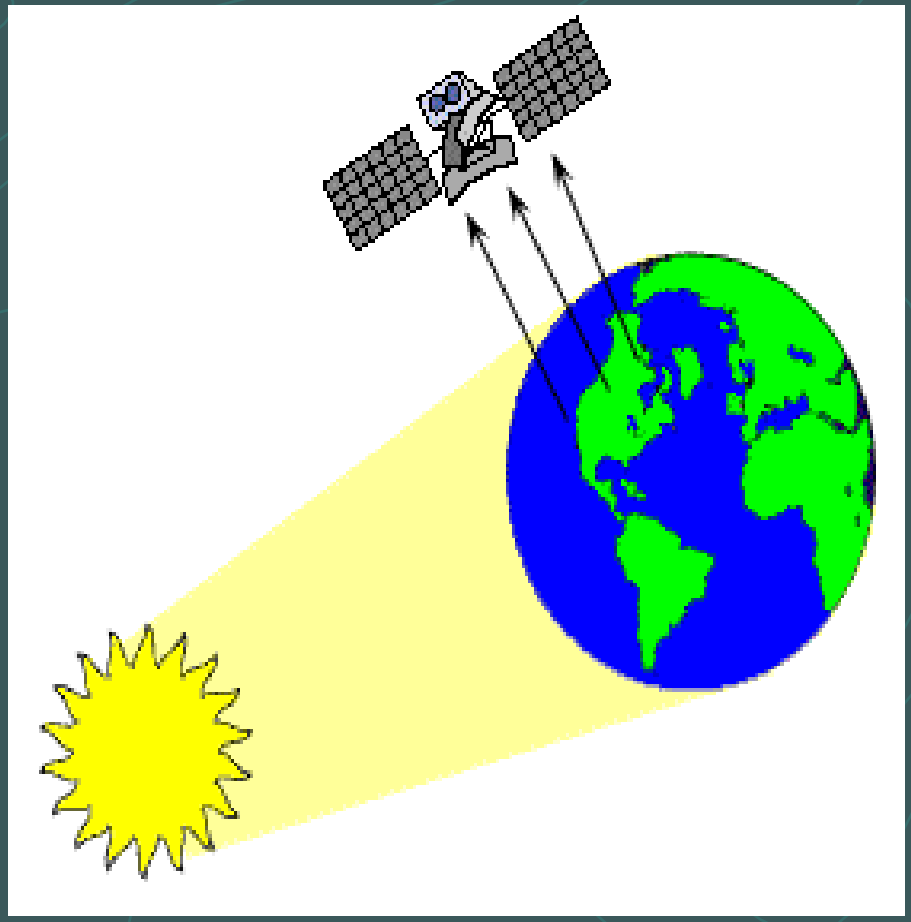
Sensors which Illuminate The objects by Their energy



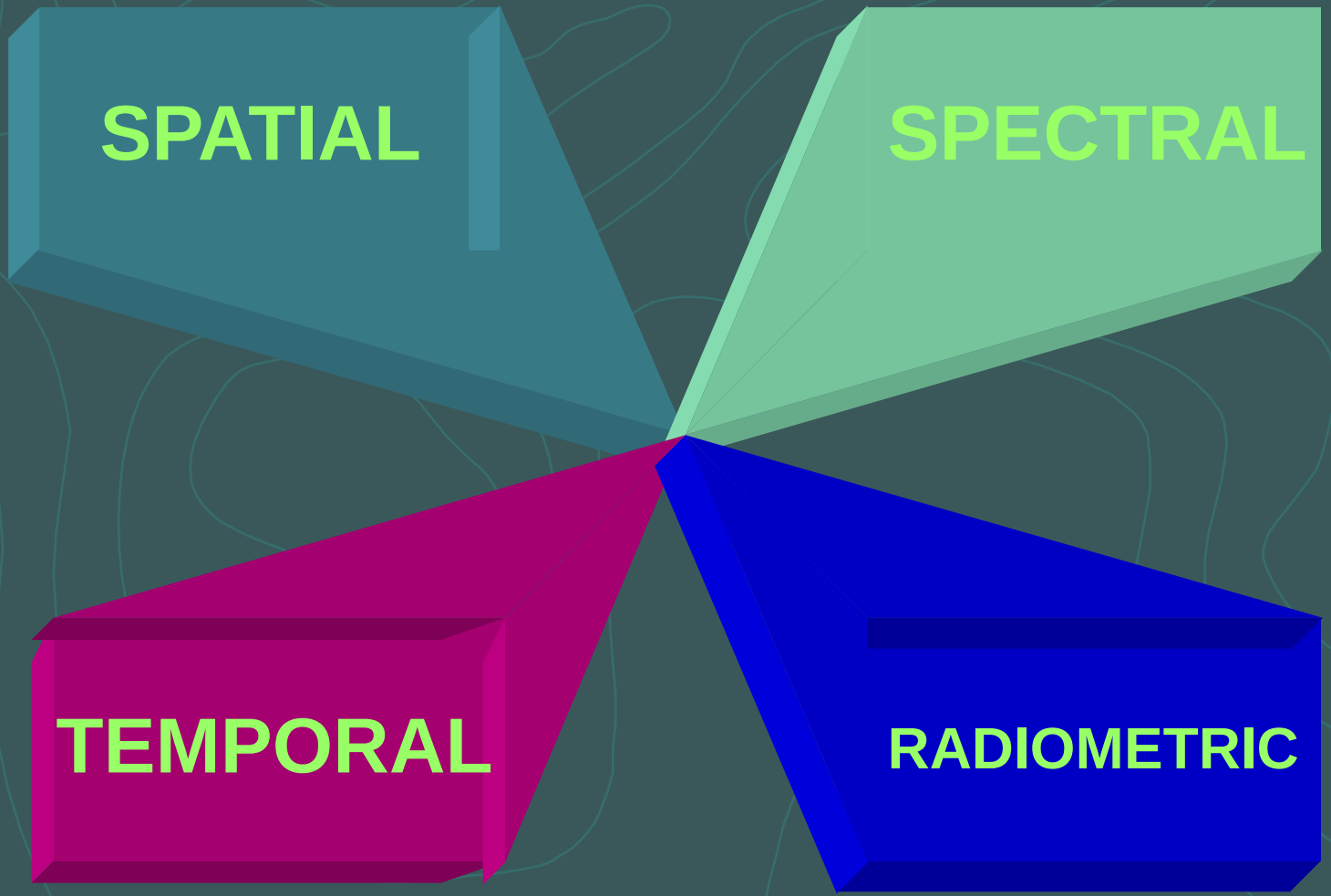
TYPES OF SENSORS

PASSIVE

Sensors which Use reflection From objects Illuminated by Natural source



RESOLUTIONS



RESOLUTION

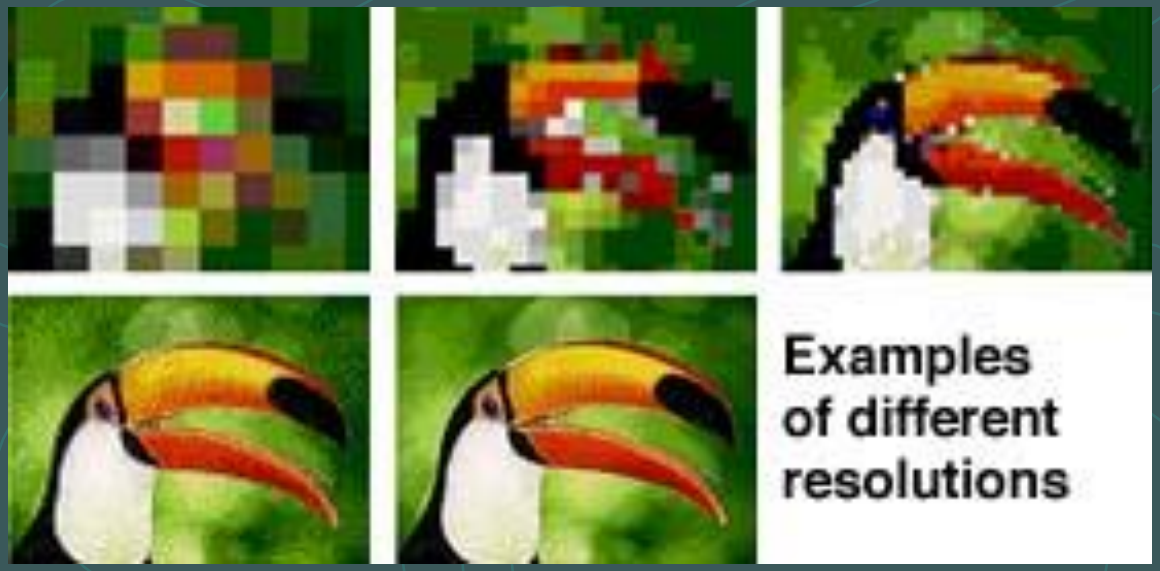
- **Spatial**: ability of sensor to distinguish small objects; defines *Pixel* size
- **Spectral**: width of bands measured by sensor
- **Temporal**: frequency of revisit time
- **Radiometric**: sensitivity of sensor to detect differences in signal strength (polarization)

SPATIAL RESOLUTION

This is defined as the smallest size of the feature that can be discriminated by the sensor

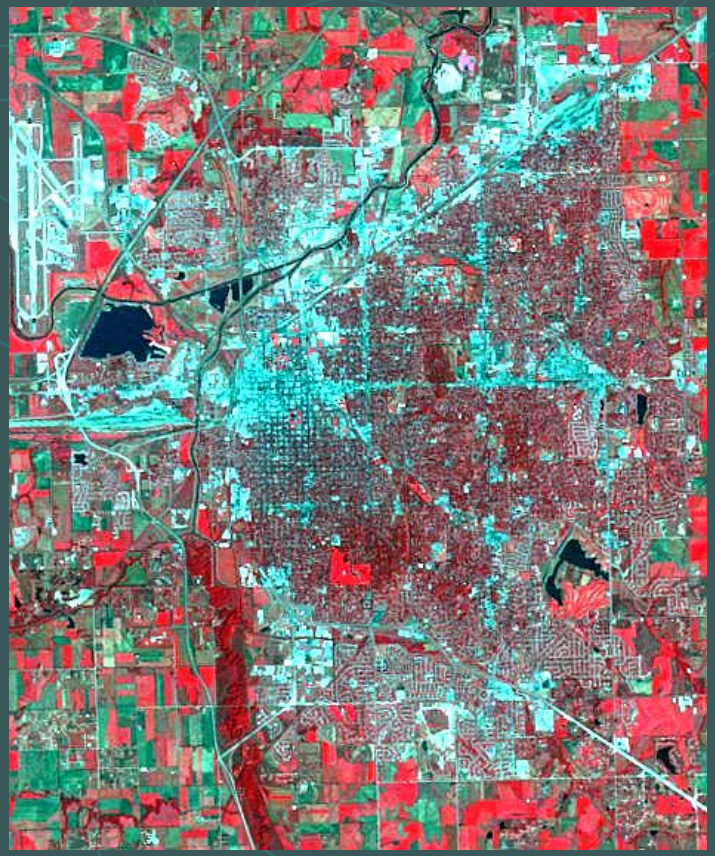
This picture element is commonly referred as pixel

Spatial Resolution



- pixel size (instantaneous field of view)
- smallest object one can discern/identify
- commonly 1 meter to 1100 meters

Spatial Resolution



Coarse (30 m, multispectral)

Fine (1 m, panchromatic, Ikonos)

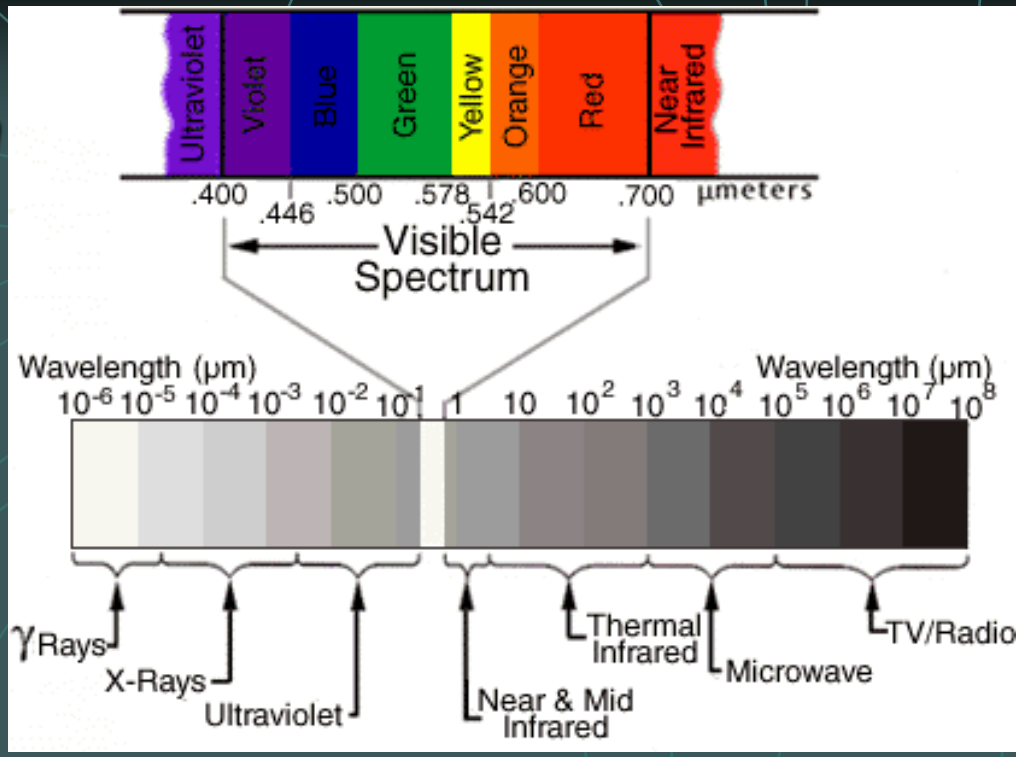
SPECTRAL RESOLUTION

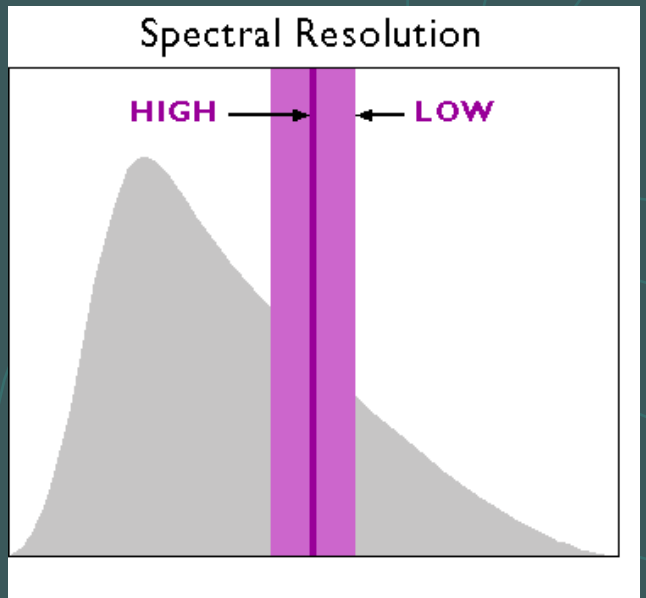
This refers to the number of wave lengths in the electro-magnetic spectrum to which a sensor is sensitive

It is preferable to have more number of spectral bands

Spectral Resolution

- how many spectral bands?
- which bands?
- band widths - narrow band vs broad band



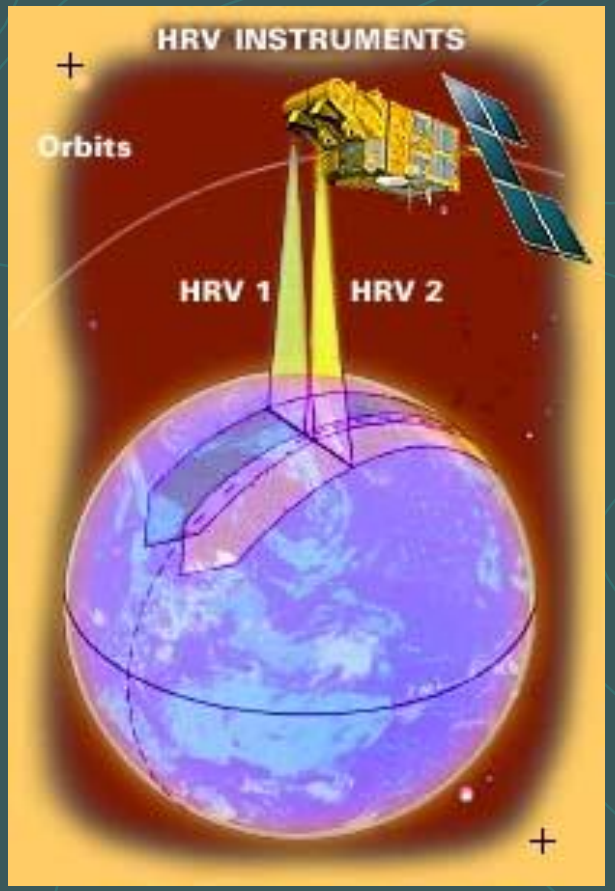


TEMPORAL RESOLUTION

This defines the repetivity of the sensor to a particular area i.e.., How frequently the sensor obtains the imagery of an area

Temporal Resolution

- how often is image available?
- varies from 1 day to 26 days (phased?)
- some sensors must be "tasked"; some are pointable
- historical archive?



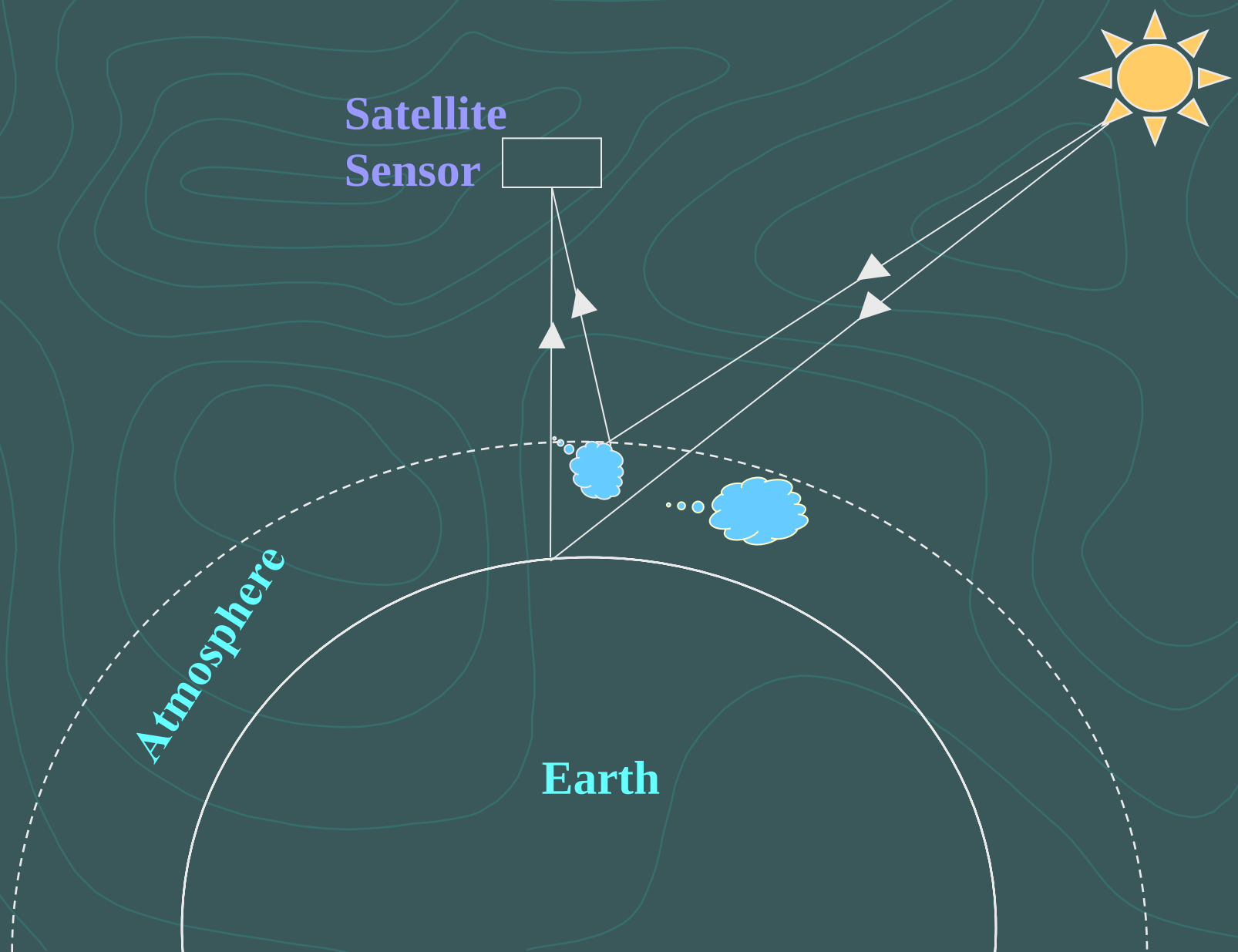
RADIOMETRIC RESOLUTION

This defines the capability of a sensor to differentiate the signal strengths of the spectral reflectance

Radiometric Resolution

- number of "brightness levels" (gray shades; bits)
- commonly 256 - 2048 levels (8 - 11 bit)

ABSORPTION OF RADIATION BY ATMOSPHERE



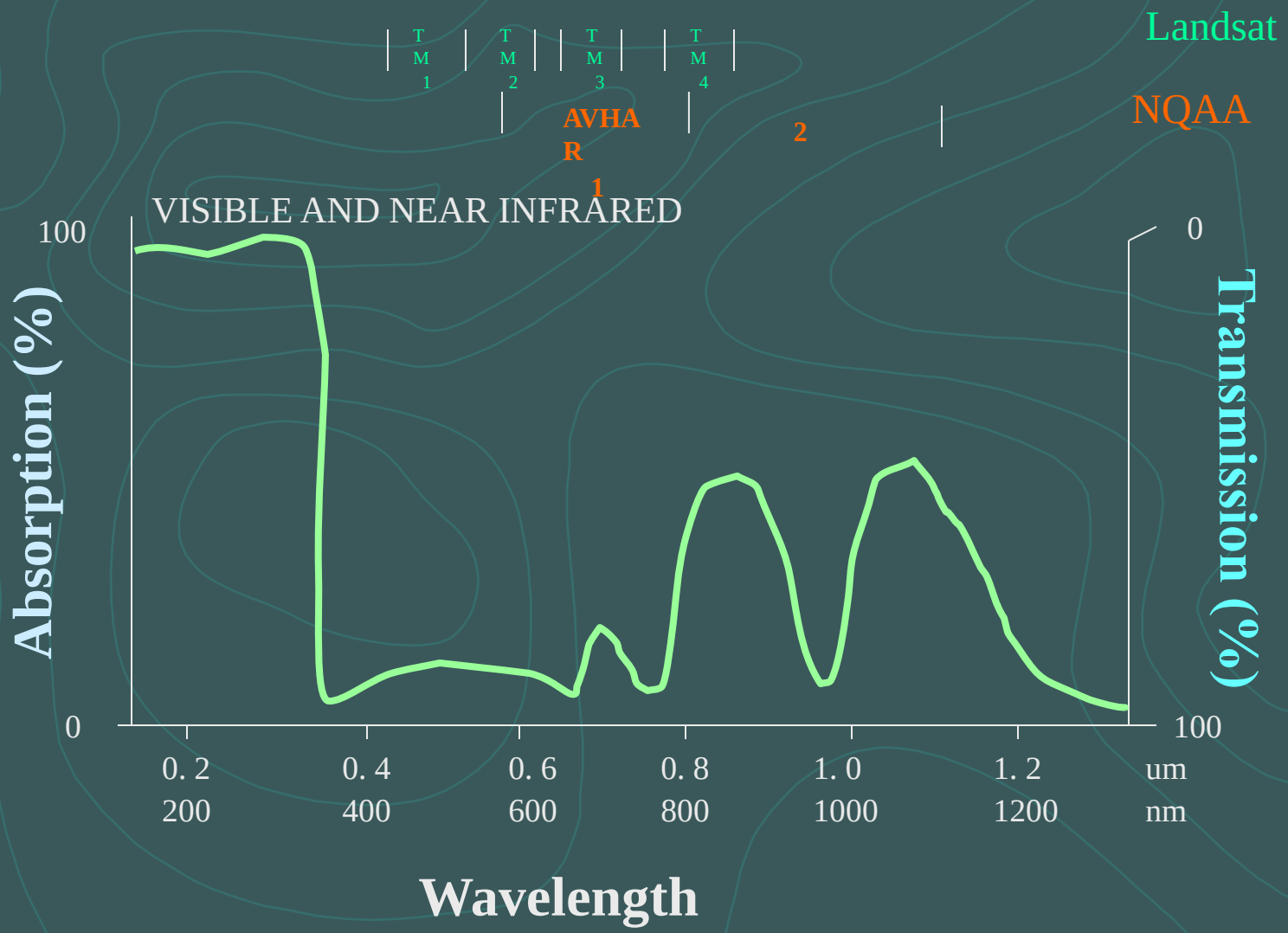
SURFACE INTERACTIONS

The radiation that is not absorbed or scattered by the atmosphere will reach the Earth's surface. Three fundamental energy interactions with the target are possible : ***absorption***, ***transmission*** or ***reflection***.

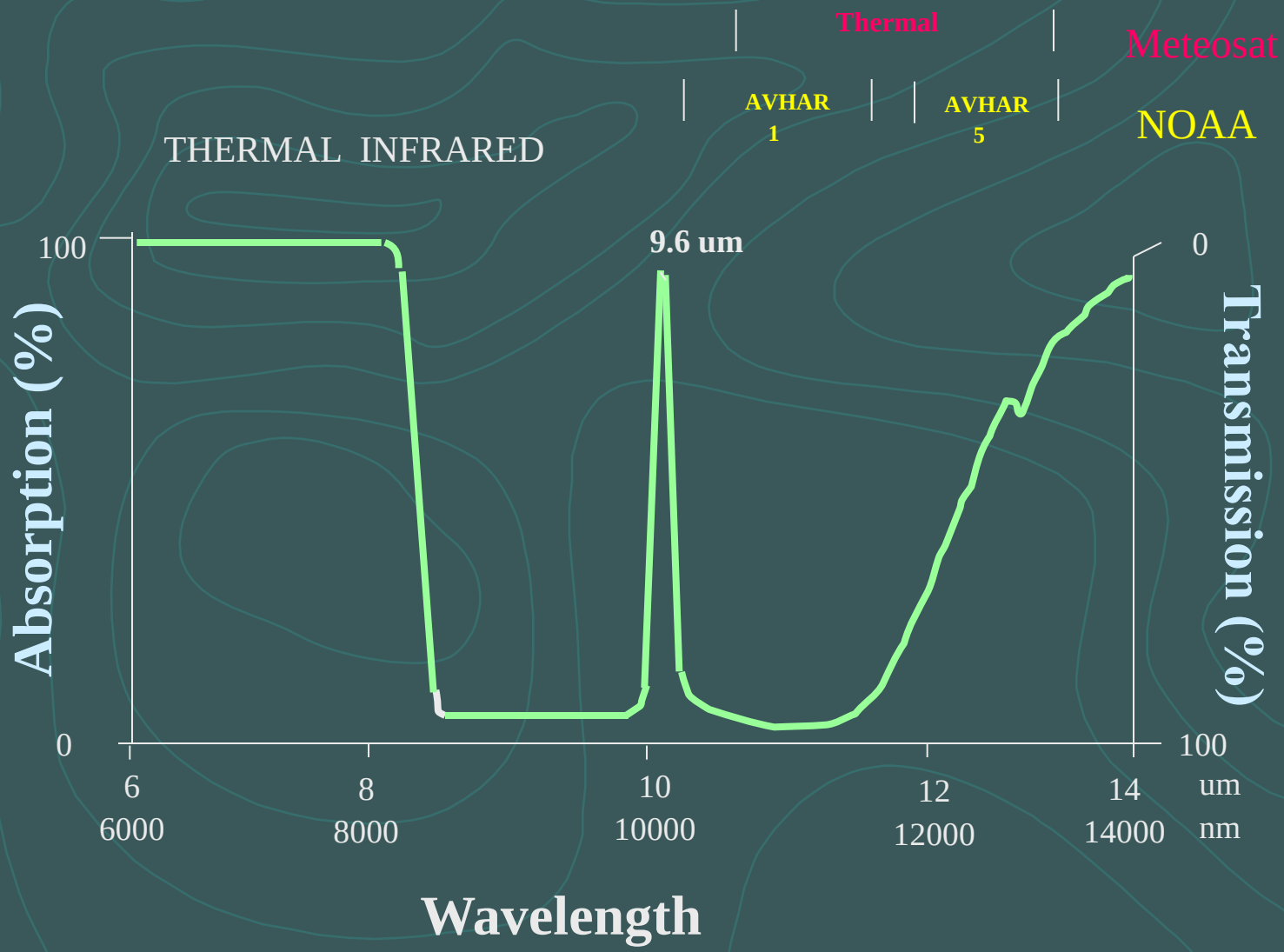
Utility for remote sensing :

different features have a different interaction pattern identification wavelength dependency

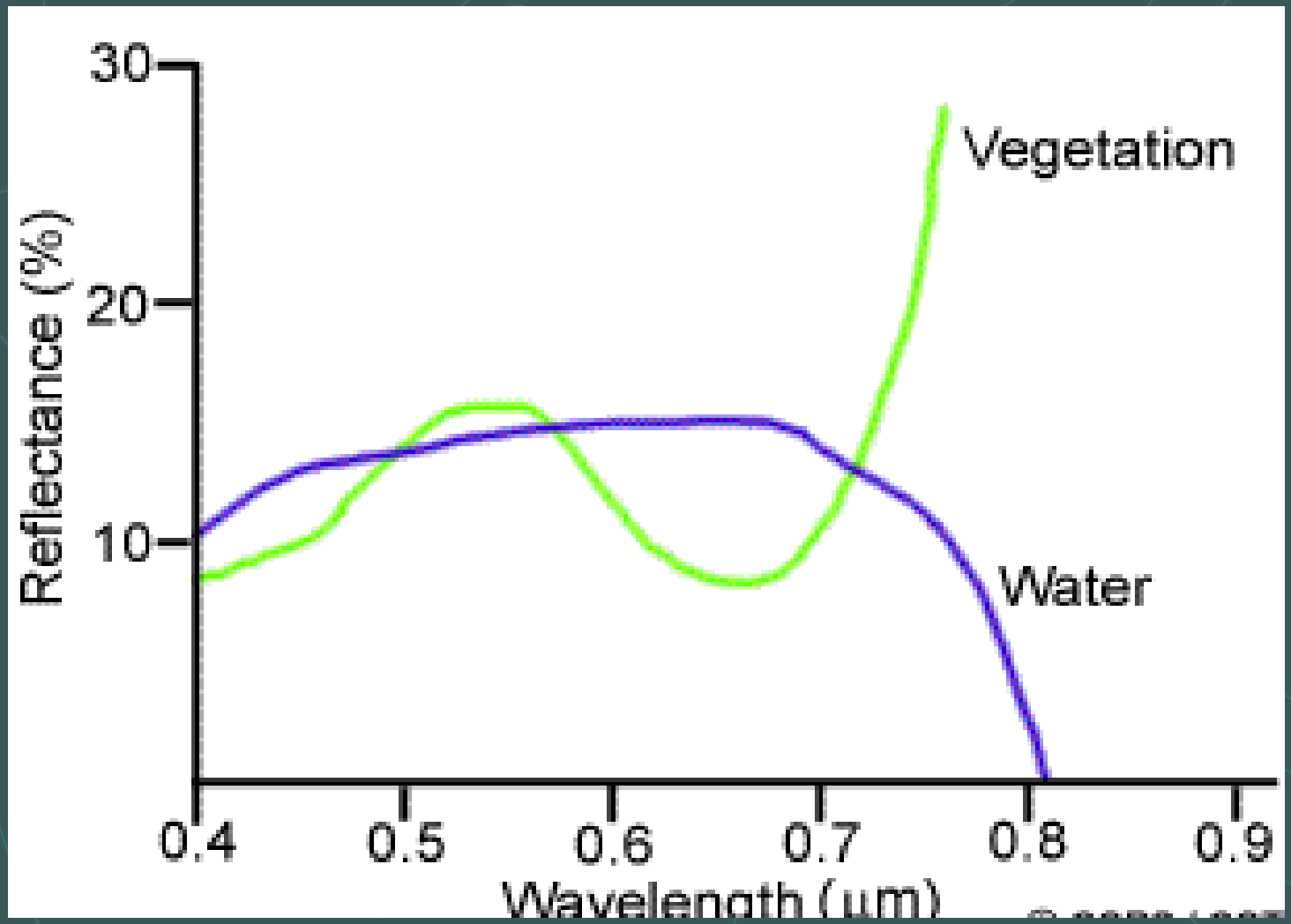
ATMOSPHERIC WINDOWS



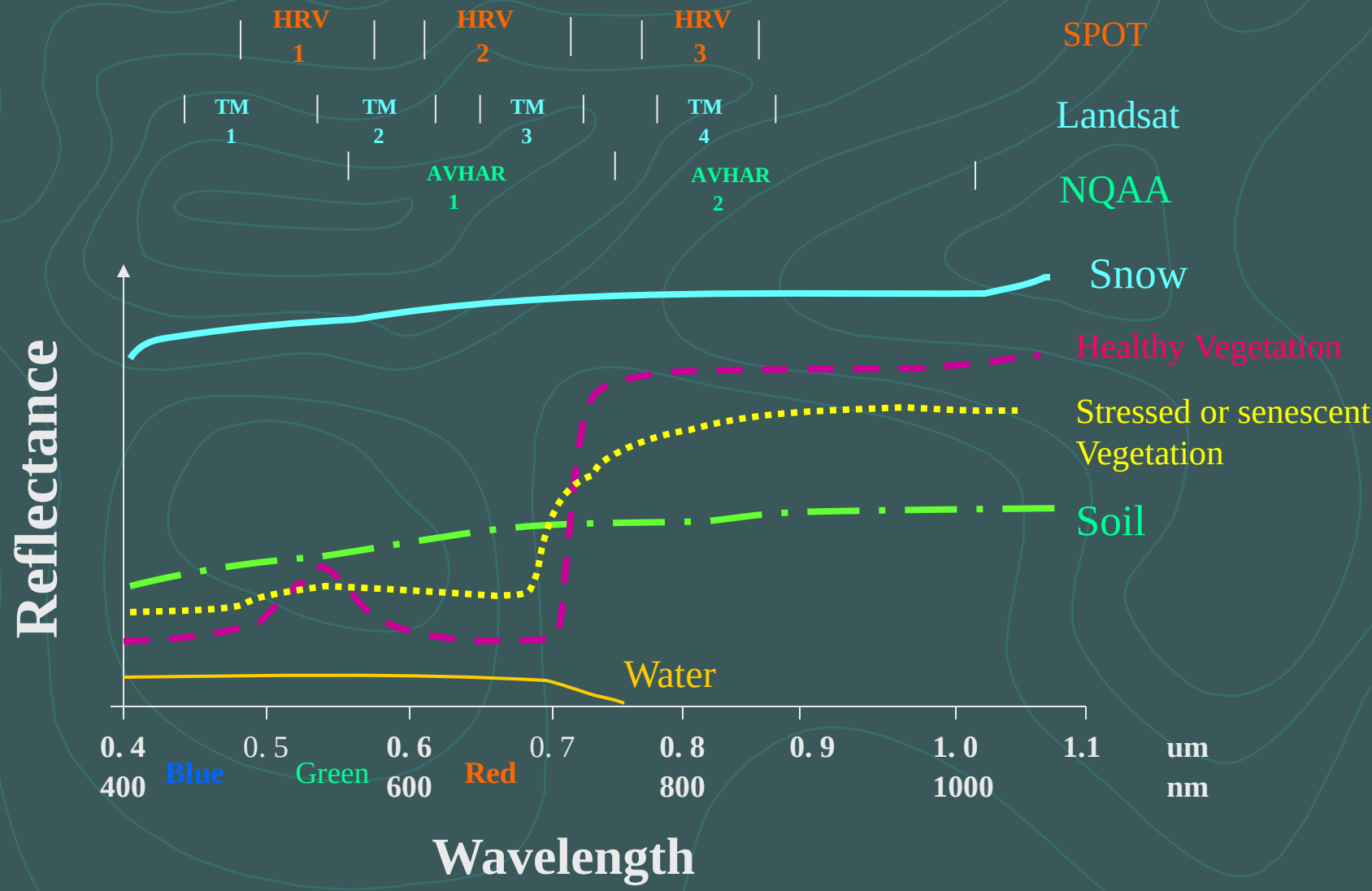
ATMOSPHERIC WINDOWS



SPECTRAL SIGNATURES



SPECTRAL SIGNATURES



MULTI IMAGING

MULTI SPECTRAL

MULTI STATION

MULTI DATE

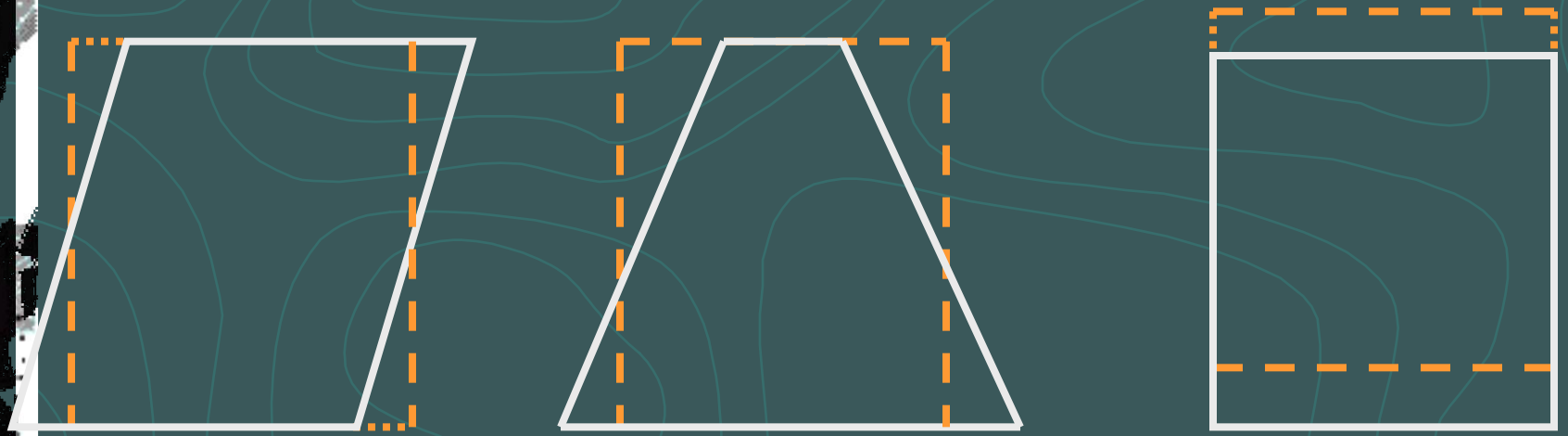
MULTI POLARISATION

MULTI DIRECTIONAL

DATA ERRORS

- **Geometric corrections**
  - Scene surface characteristics
  - Stability and orbit cht. Of satellite platform
  - Earth's motion and curvature
- **Radiometric corrections**
  - Cht. Of sensor
  - Non-uniformity of illumination
  - Atmospheric effects

GEOMETRIC CORRECTIONS

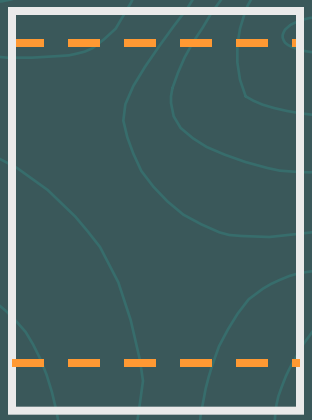


Earth rotation

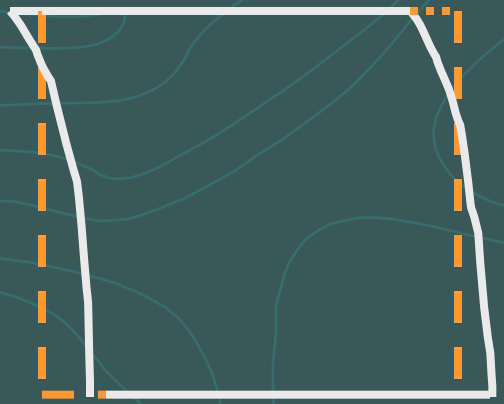
Altitude variation

Pitch variation

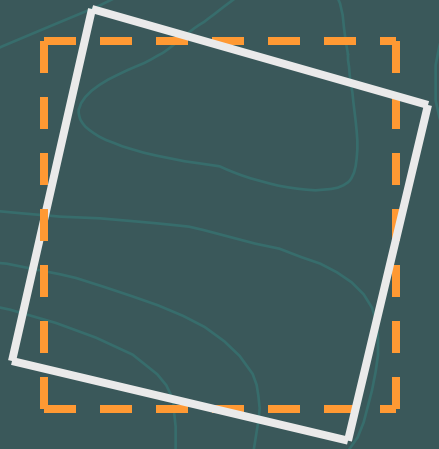
GEOMETRIC CORRECTIONS



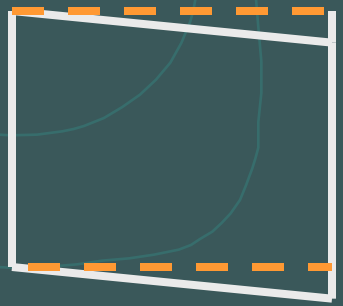
Spacecraft velocity



Roll Variation



Yaw Variation

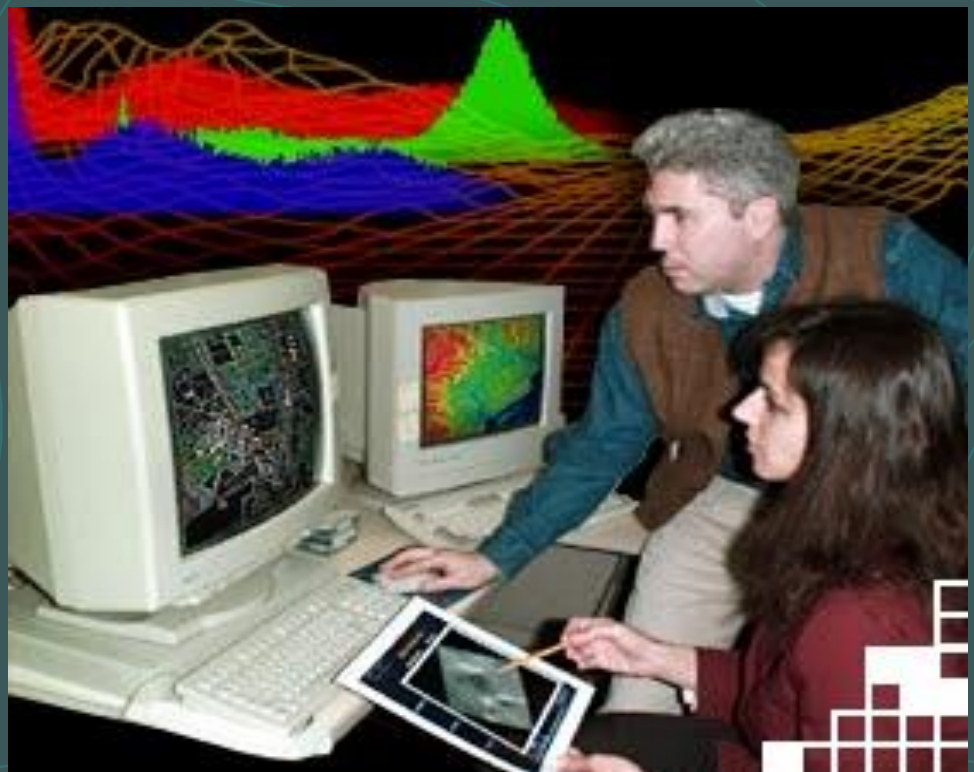


Scan Skew

Image Analysis

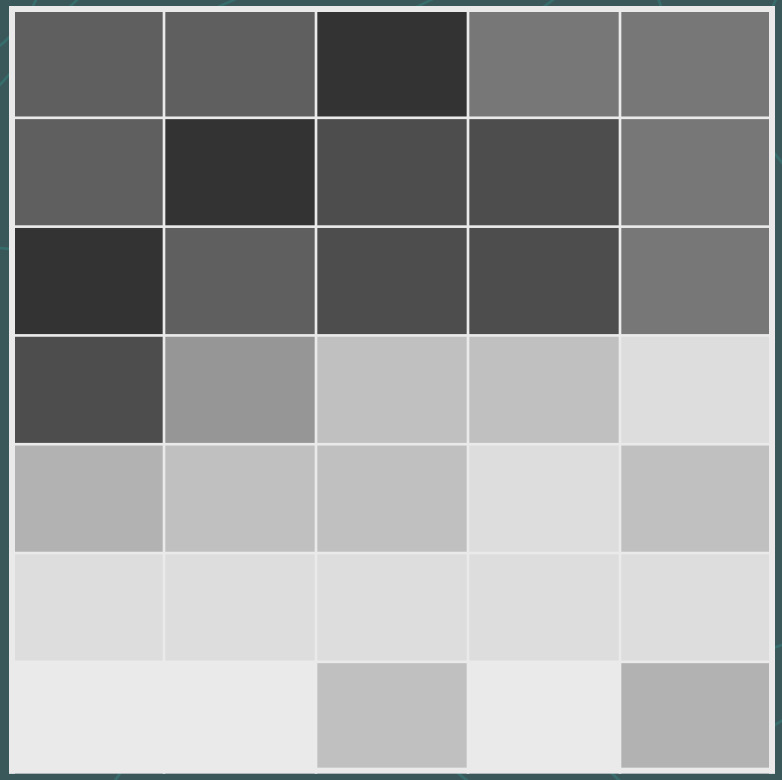
Interpretation and identification of targets in remote sensing imagery is performed

- **manually or visually, i.e. by a human interpreter.**
- **using Software & processing tools - imagery displayed in a pictorial or photograph-type format,**



Digital Image

25	22	19	47	44
22	18	25	22	44
19	21	22	23	42
21	116	121	125	134
118	125	123	135	126
125	133	136	221	234
244	243	212	232	178



- Pixel (picture element)

Image Analysis

- Acquisition
- Geo-processing and Geo-rectification
- Atmospheric and Topographic Correction
- Analysis
- Classification
- Applications

Applications

Agriculture :Crop type mapping, crop type identification

Forestry : clearcut mapping, species identification, burn mapping

Geology : structural mapping, geologic units

Landcover and Landuse : rural/urban change, biomass mapping

Mapping : Digital Elevation Models (DEM), topographic mapping

Oceans and Coastal : Ocean features, ocean colour, oil spill detection, pollution control

WATER RESOURCES STUDIES

- Surface water inventory
  - Water depth penetration
  - Water temperature
- Soil moisture studies
- Watershed delineation and characterisation
- Water quality mapping and monitoring
- Irrigation management
- Reservoir sedimentation
- Flood management
- Drought monitoring
- Catchment runoff estimation
- River morphology
- Coastal erosion
- Evaporation & evapo-transpiration studies
- Ground water studies

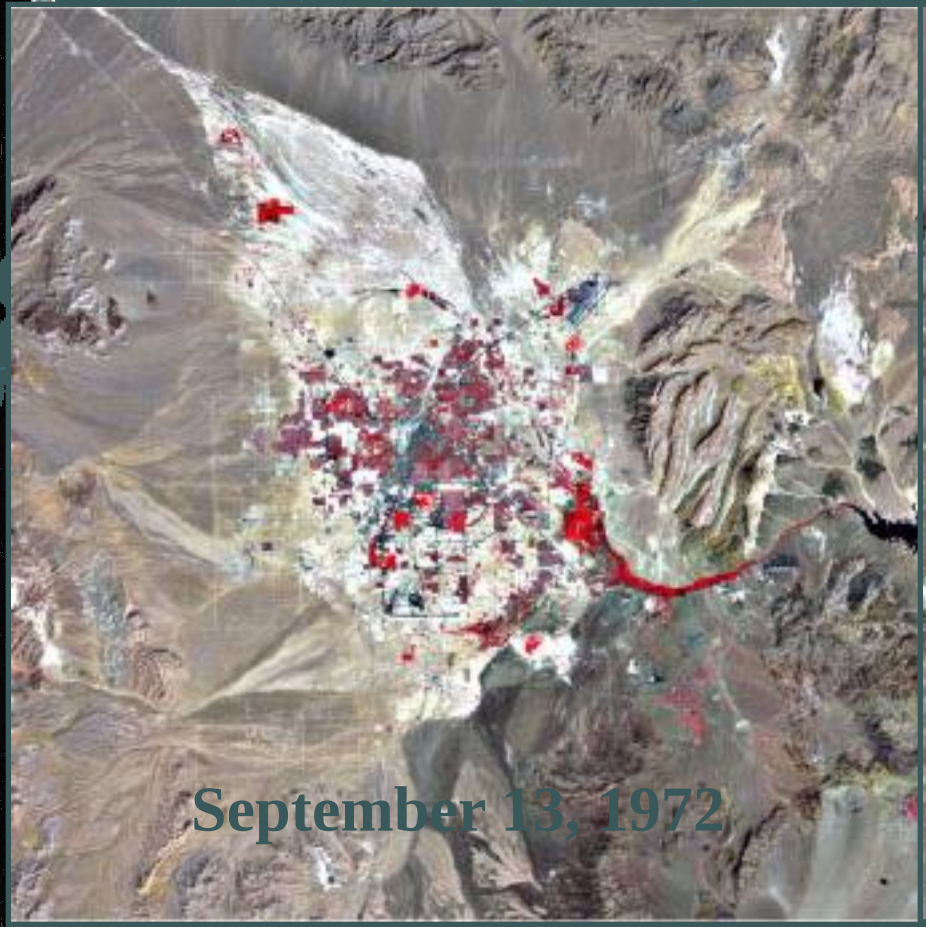
SPECTRAL BANDS USEFUL FOR WATER RESOURCES STUDIES

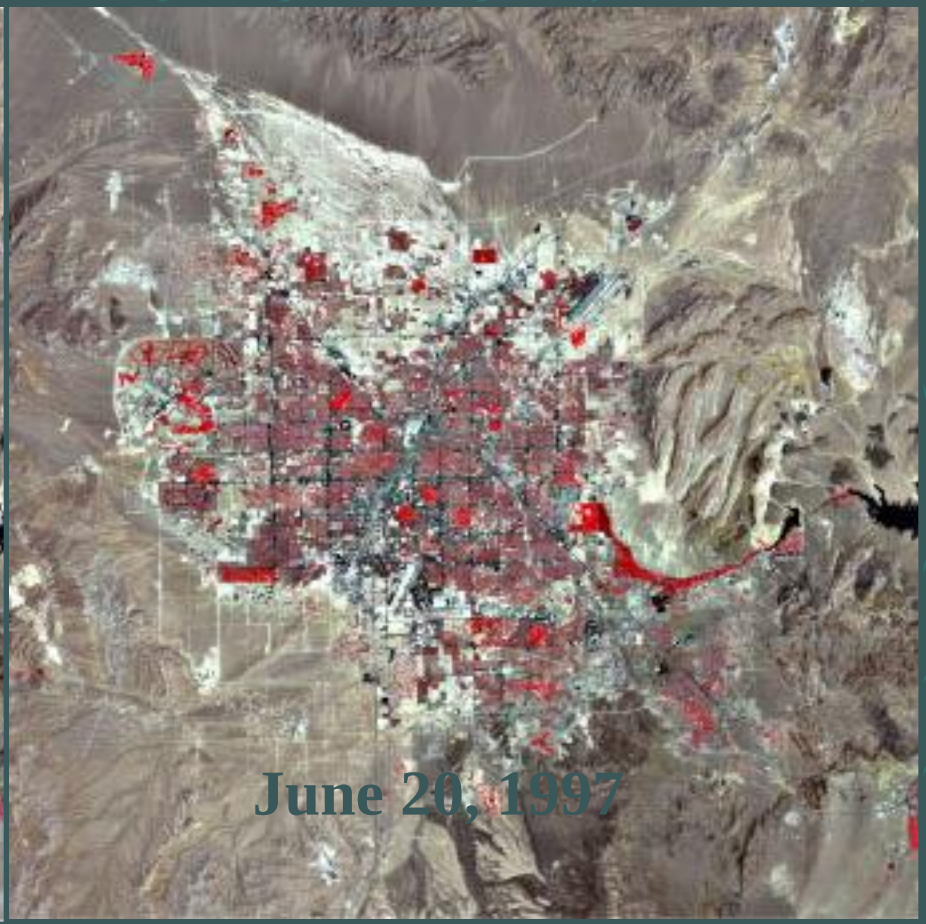
- **Blue and green(shorter) for water depth and water quality studies**
- **NIR band for land water discrimination**
- **Thermal band for land use and crop water status**
- **3-14 um is useful for general WR studies**
- **Microwave for soil moisture , stream flow runoff estimation studies**
  - **All time all weather capability**
  - **Ability to penetrate clouds and few cms of Soil**

GROUND TRUTH TOOLS

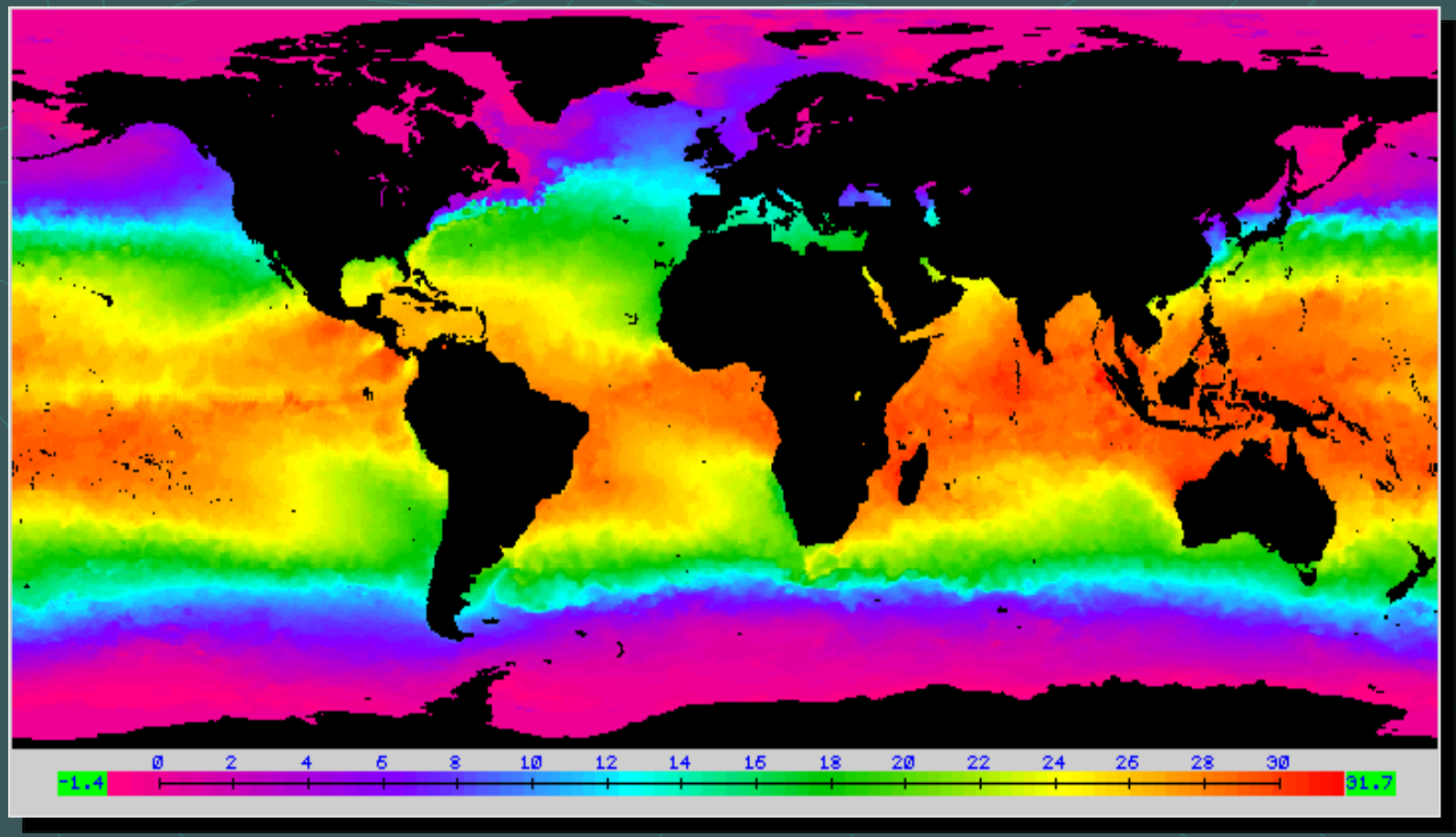
- Toposheets or maps
- Imagery
- Global positioning system
- Spectrometer
- Radiometer
- Agro photometer
- Leaf area index meter

Landsat Change Analysis



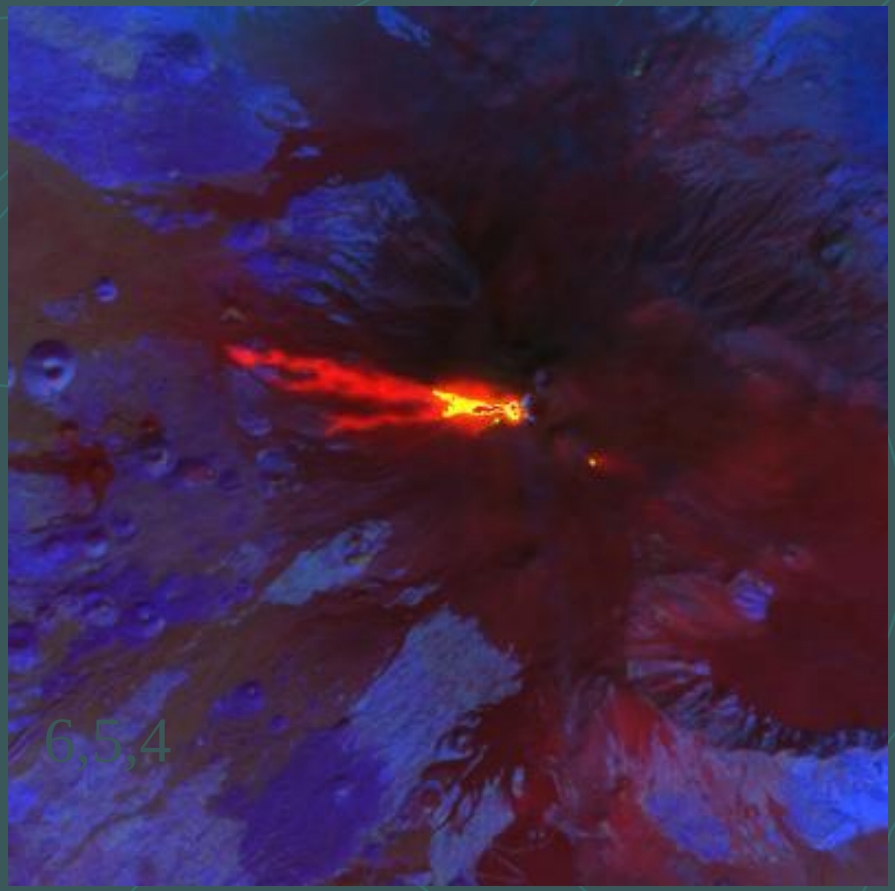


Worldwide Sea-surface Temperature (SST) Map Derived From NOAA-14 AVHRR Data



Jensen, 2000

Monitoring Volcanic Eruptions



Thanks